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An Empirical Algorithm for Retrieving Land Surface Temperature From AMSR-E Data Considering the Comprehensive Effects of Environmental Variables

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Key Points:
- Topographic effect is considered for the first time in the microwave land surface temperature retrieval
- A classification system involving various factors on land surface temperature distribution is constructed
- Accuracy of the AMSR-E LST in China retrieved from the proposed algorithm has been obviously improved compared to the previous algorithms

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Abstract Microwave (MW) remote sensing has the potential to obtain all-weather land surface temperature (LST) and serves as a complement to the thermal-infrared (TIR) LST under cloudy sky conditions. However, the accuracy of MW LST is generally lower than that of TIR LST, making the retrieval of highly accurate all-weather LST a challenging task. We propose an empirical algorithm for retrieving LST from the Advanced Microwave Scanning Radiometer (AMSR-E) brightness temperature (BT) data. First, we constructed a comprehensive classification system of environmental variables (CCSEV), allowing for the influence of topography, land cover, solar radiation, and atmospheric condition on the spatiotemporal distribution of LST, then the LST was expressed as a function of the combination of different AMSR-E channels for each CCSEV class. When performing the testing with the data from 2005, 2009 and 2011, the accuracy is 3.27 K, 2.65 K and 3.48 K in the daytime and 2.94 K, 2.63 K, 2.15 K at nighttime, respectively. The proposed algorithm was compared to an existing algorithm developed for China without considering the topography. The result shows that the accuracy of LST has improved by 2.81 K in the daytime and 2.14 K at nighttime in China, compared with the Moderate Resolution Imaging Spectroradiometer (MODIS) LST. The verification at the Naqu sites in the Qinghai-Tibet Plateau shows that the accuracy has improved by 1–2 K in the daytime and 0.7–1 K at nighttime. These results indicate that the developed algorithm is universal and accurate and benefits the retrieval of accurate all-weather LST.

1. Introduction

Land surface temperature (LST) is one of the critical environmental indicators for the study of energy balance and material exchange near the Earth's surface. It is extensively employed in fields such as evapotranspiration estimation, hydrologic cycle research, vegetation monitoring, urban heat island research, disaster prediction, and crop yield estimation (Anderson et al., 2008; Cheng & Kustas, 2019; Kalma et al., 2008; Li et al., 2009; Trenberth et al., 2007; Zhang & Cheng, 2019; Zhou et al., 2011).

Remote sensing is a unique means for acquiring LST on the regional and global scales. Generally, we can derive LST from thermal-infrared (TIR) and microwave (MW) observations with specifically designed retrieval algorithms. It is well recognized that the TIR algorithm is much more developed and the retrieved LST has a relatively high spatial resolution and accuracy (Li et al., 2013b). There are already some released TIR LST products, including the Moderate Resolution Imaging Spectroradiometer (MODIS) LST (https://lpdaac.usgs.gov/), the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) LST (http://asterweb.jpl.nasa.gov/), the Visible Infrared Imaging Radiometer (VIIRS) LST (https://lpdaac.usgs.gov/), and Spinning Enhanced Visible and Infrared Imager (SEVIRI) LST (http://www.esa.int/), etc. However, the TIR signal is sensitive to the atmosphere and cannot penetrate the clouds, which prevents the onboard TIR sensor from capturing the land surface information and results in a serious data gap in the produced LST products (Jin, 2000). In contrast, MW can penetrate clouds, making the retrieval of all-weather LST possible. According to the literature review, many studies have been conducted to retrieve the LST from the observations of the Scanning Multichannel Microwave Radiometer (SMMR), the Special Sensor Microwave/Image (SSM/I), the Tropical Rainfall Measuring Mission Microwave Imager (TMI), the Advanced Microwave Scanning Radiometer (AMSR, named AMSR-E on satellite Aqua and AMSR2 on satellite GCOM-W), etc.